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(74) Agent: ELLA CHEONG MIRANDAH & SPRUSONS
PTE LTD; 111 North Bridge Road, #22-01 Peninsula
Plaza, 179098 Singapore (SG).

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(71) Applicant (for all designated States except US): AURI-
GIN TECHNOLOGY PTE LTD [SG/SG]; Blk 4010,
Ang Mo Kio Ave. 10, #07-09, TECHplace 1, 569626
Singapore (SG).

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(72) Inventors; and

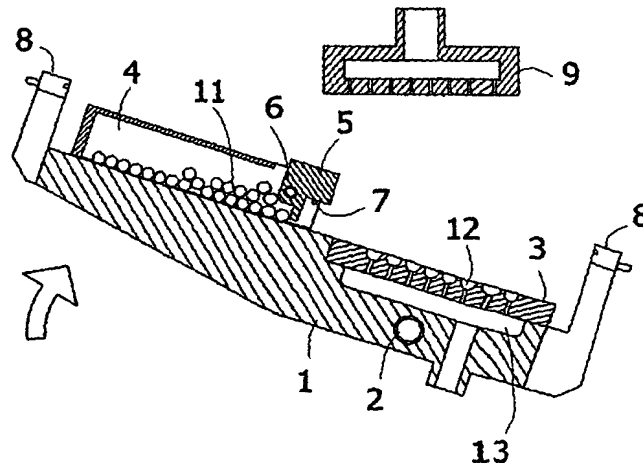
(75) Inventors/Applicants (for US only): NG, Boon Chew
[SG/SG]; Blk 340, Chua Chu Kang Loop, #09-15, 680340
Singapore (SG). TAM, Wing Wah [SG/SG]; 27 Hai Sing
Crescent, 538961 Singapore (SG). LIM, Ee Teoh [SG/SG];
49 Jalan Raja Udang, #11-63, 329210 Singapore (SG).

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ning of each regular issue of the PCT Gazette.

(54) Title: AN APPARATUS AND METHOD FOR FILLING A BALL GRID ARRAY TEMPLATE



(57) Abstract: An apparatus and method for filling a ball grid array template (3) is disclosed. The apparatus comprises a normally horizontal base plate (1) with the ball grid array template (3) being mounted onto the base plate at one end. A solder ball supply bin (4) is slidably mounted over the surface of the base plate (1). The bin (4) is enclosed on three vertical sides, while the fourth vertical side proximate the ball grid array template (3) is a pivotable ball gate (5). At rest, the bin (4) is located at an end of the base plate (1) opposite to the template (3). When the base is tilted, the bin (4) slides from its rest location to the other end of the base plate, so that it is positioned over the template (3), thereby allowing the solder balls (11) to fill the locating holes (12) of the template (3). The base is then rotated so that it tilts the opposite way, allowing the bin (4) to return to its rest position. As the bin returns to its rest position, the ball gate (5) sweeps any excess balls (14) on the surface of the template (3) back into the bin (4). A sensing device (8) monitors the position of the ball gate (5). If the ball gate (5) is in an open position, this indicates an abnormality in operation.

TITLE OF THE INVENTION

AN APPARATUS AND METHOD FOR FILLING A BALL GRID ARRAY
TEMPLATE

BACKGROUND OF THE INVENTION

Field of the invention

The present invention generally relates to ball grid array (BGA) and in particular, an apparatus and method for filling a ball grid array template with solder balls.

Description of the Prior Art

Ball grid arrays techniques are common nowadays for connecting high-density IC components onto circuit boards. US Patent No. 5,655, 704, issued to Matsushita Electric Industrial Co., 12 August 1997 discloses a method of filling a template or a stencil with solder balls as a sweeping bin passes over the template. However, such method is very susceptible to solder ball damage by the design itself as well as due to process variability, contamination or foreign particle. As a result of the damage, subsequent process becomes not possible or the object of subsequent depositing the solder ball on the BGA package is not possible.

FIG. 1 shows a conventional method of filling a BGA template with solder balls. The BGA template 1 is provided with a plurality of holes to receive a plurality of solder balls 3. A ball bin 2 sweeps over and above the template 1 and deposits the solder balls 3 into the holes on the template 1. As this deposition of the solder balls 3 can happen anytime when the solder ball 3 and the hole are aligned, the deposition may take place just as the ball bin 2 is about to reach the particular hole at which the solder ball 4 is just about to drop in. As shown in FIG. 1, this may result in the ball 4 being quashed by the bin 2. Another possible situation is when the solder ball 6 fails to properly seat in the hole due to foreign matter 5. The bin 2 will shear off the top of the solder ball 6.

FIG. 2 is a perspective view showing a solder ball mounting apparatus disclosed in US Patent No. 5,655, 704. As shown in the FIG. 2, the solder balls are deposited onto the substrate 10 through the stencil 7. The flux dots 11 on

the substrate hold the solder balls 9 in place. However, as these flux dots 11 are liquid paste, the volume or height of the dot 11 may vary as in the case of flux dot 12, where there is excessive amount. This causes the solder ball 13 to stick out of the stencil 7 and be sheared off at the top as the solder ball bin 8 passes over the ball 13. There can potentially be cases where there is not any flux dots and the solder balls will drop lower than the usual height and the solder ball 14 will be sheared by the bin 8.

US Patent No. 5,499,487, issued to Vanguard Automation, Inc., 19 March 1996 discloses an apparatus for placing solder balls in a ball grid array. The apparatus comprises a wheel having an inner and an outer face, and the wheel being rotatable about a horizontal axis, means for attaching a ball grid array to the inner face of the wheel, means for attaching a tooling fixture to the outer face of the wheel in a position corresponding to that of the ball grid array, means for forming a reservoir of solder balls at the bottom of the wheel, means for controllably rotating the wheel to move the tooling fixture through the reservoir in a manner to fill recesses in the fixture with solder balls and to remove from the surface of the array any excess solder balls which are not occupying recessed, the inner and the outer faces being separated a distance to permit the tooling fixture to engage solder balls in the reservoir while ball grid array does not engage the solder balls.

US Patent No. 5,551,216 relates to a method and apparatus for filling a ball grid array. The apparatus comprises a reservoir for solder balls and a tooling plate with an array of holes for receiving solder balls. US Patent No. 6,276,598 relates to a method and an apparatus for ball placement. The method and apparatus are particularly suitable for transferring solder balls to a ball grid array package.

The methods disclosed in the above US Patents Nos. 5,499,487, 5,551,216, and 6,276,598 make use of free flow of solder balls 17 over tilted templates 15 with or without vacuum suction at the holes receiving the solder balls. This method does not prevent excess solder balls 18 and solder balls 19 remaining on the surface of the template or around the holes due to either static forces, vacuum leakage at holes or foreign matter which may be sticky like flux

used in the attachment to the substrate. In these citations, subsequent operation whereby the ball pick head 16 or a ball grid array substrate 20 is advanced above the template will result in quashed solder ball or multiple balls at each hole in the pick head or at each electrode on the ball grid array (as shown in FIGS. 3 and 4).

US Patent No. 5,918,792, issued to RSVI Vanguard, Inc., 6 July 1999, discloses ball grid arrays and method for placement of solder balls onto the pattern of metallized pads or dots of such arrays. The apparatus comprises an elongated holder defining an elongated recess therein for the carrier of the array, a stencil overlying the recess and supported by guide rails, a block of rigid material having a planar bottom surface contacting the stencil and for movement along the stencil, and means for moving the block along the stencil for moving a bin contacting solder balls over the apertures formed on the stencil for filling the apertures.

SUMMARY OF THE PRESENT INVENTION

Accordingly it is an object of the present invention to provide an apparatus and method for filling a ball grid array template with solder balls. Yet another object of the present invention is to provide an apparatus for filling a ball grid array template having locating holes with a plurality of small solder balls comprising

a base plate rotatably mounted at the axis thereof to a controlling device and the ball grid array template being mounted onto the base plate so that the template rotates simultaneously with the base plate;

a ball supply bin slidably mounted over the top surface of the base plate while being rotated together with the base plate, the sliding motion of the ball supply bin being controlled by a driving means such as a motor, and the ball grid array template about the axis of the base plate, and the ball supply bin being substantially rectangular and enclosed on three vertical sides while the fourth vertical side proximity to the ball grid array template being a ball gate, said ball gate pivoted about the axis thereof and being normally rested by a stop pin or the like, such as a stopping edge, positioned at the lower surface of the ball gate;

a sensing device positioned at both the ends of the base plate at a height similar to the height of the ball gate from the base plate for monitoring the opened/closed position of the ball gate; and

a plurality of small solder balls enclosed by the ball supply bin
5 thereby when the base plate tilted towards the ball grid array template, the bin supply bin slides to and over the ball grid array template and thereby fill up the locating holes on the template with solder balls, the base plate is then tilted in the opposite direction, the ball supply bin slides back to the other end and simultaneously, the excess solder balls are fallen back with the supply bin.

10 Yet a further object of the present invention is to provide a method of filling solder balls on a ball grid array template having a plurality of locating holes, said method comprising the steps of:

positioning said ball grid array template at one end of a pivotal base plate;
introducing a plurality of solder balls in a ball supply bin which is slidably

15 positioned at the one end of the base plate, and is slidable on the base plate;
clockwise rotating of the base plate, causing the ball supply bin sliding towards the ball grid array template to allow the solder balls contained in the ball supply bin to fill the locating holes on the template, and the sliding motion of the ball supply bin being controlled by a driving means such as a motor, each

20 solder ball for each locating hole; and

counter-clockwise rotating of the base plate and sliding of the ball supply bin back to its initial position and, in so doing, remove any excess solder balls from above the ball grid array template.

A further object of the present invention is to provide an apparatus for
25 filling solder balls on a ball grid array template, further comprising a ball pick head which is lowered above the ball grid template to remove the solder balls by vacuum for transferring to a ball grid array substrate.

Yet another object of the present invention is to provide a method of filling solder balls on a ball grid array template, wherein the base plate is tilted
30 clockwise in an angle ranging from 5 to 40 degree above horizontal.

Yet another object of the present invention is to provide a method of removing excess solder balls from a ball grid array template, wherein the base plate is tilted anti-clockwise in an angle ranging from 20 to 75 degree.

An embodiment of the invention will now be described by way of example and with reference to the accompanying drawings, in which

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a partly enlarged cross-sectional view showing a conventional solder ball mounting apparatus.

FIG. 2 is a cross-sectional view of another conventional solder ball mounting apparatus.

FIGS. 3 and 4 schematically show instances which may result in quashed solder ball or multiple balls at each hole in the pick head or at each electrode on the ball grid array in a conventional solder ball mounting apparatus.

FIG. 5 is a cross-sectional view showing the depositing of solder balls from the ball supply bin to the ball array template in accordance with the present invention.

FIGS. 6 to 15 are cross-sectional views showing operation sequence of depositing of solder balls in accordance with the present invention.

DETAILED DESCRIPTION OF THE PRESENT INVENTION

While the specification concludes with claims defining the features of the invention that are regarded, it is believed that the invention will be better understood from a consideration of the following description in conjunction with the drawings.

Referring now to FIG. 5, there is shown an apparatus for filling solder balls on a ball grid array template in accordance with the present invention. The apparatus comprises a base plate 1 rotatably mounted at the axis 2 thereof to a controlling device; a ball grid array template 3 mounted onto the top surface of the base plate 1 at one end thereof so that the ball grid array template 3 rotates simultaneously with the base plate 1 when the base plate 1 rotates (tilts) clockwise or anti-clockwise; a ball supply bin 4 substantially rectangular shape

slidably mounted over the top surface of the base plate 1 at the other end thereof and corresponding to the position of the ball grid array template 3 and the ball supply bin is driven by a motor and is moveable along the base plate 1 while the base plate 1 rotates about the axis 2 of the base plate 1. In accordance with the present preferred embodiment, the ball supply bin 4 is enclosed on three vertical sides while the fourth vertical side, proximity to the ball grid array template 3, is provided with a ball gate 5. The ball gate 5 is pivoted about the axis 6 thereof and is normally rested by a stop pin 7 positioned at the lower surface of the ball gate 5 when the base plate 1 rotates clockwise or counter-clockwise. The ball grid array template 3 is provided with a plurality of locating holes 12 on the top surface to hold solder balls 10, and one locating hole 12 receives only one solder ball 10, as shown in FIG. 5.

A sensing device 8, such as a through-beam sensor, or a focused-beam reflective sensor is positioned and supported at both the ends of the base plate 1 at a height similar to the height of the ball gate 5 from the base plate 1 for monitoring the opened/closed position of the ball gate 5. If the ball gate 5 is in an open position, this indicates an abnormality in operation. The ball gate 5 is designed in such a way that the weight of the ball gate 5 is pivoted about the axis 6 and the weight will ensure that the ball gate 5 forms a close wall to contain the solder balls 11 within the ball supply bin 4.

As shown in FIG. 5, a plurality of small solder balls (in bulk) 11 are enclosed by the ball supply bin 4. A ball pick head 9 is positioned above the ball template 3 and is lowered to remove the solder balls 10 on the ball grid array template 3 by vacuuming for transferring to a BGA substrate 19 (referring to FIG. 15).

In accordance with the present invention, a vacuum 18 is provided to a chamber 13 underneath the ball grid array template 3, in communication with the individual locating holes 12 on the ball grid array template 3 so as to assist the filling of the solder balls 10 (referring to FIG. 7 and FIG. 8).

FIGS. 7 through 15 depict the operation of the apparatus in accordance with the present invention.

At the initial operation of the apparatus, the base plate 1 together with the ball grid array template 3 having no solder balls 10 on the locating holes 12 are in the horizontal position (as shown in FIG. 6). As shown in FIG. 6, the solder balls 11 are contained within the ball supply bin 4 and the ball gate 5 is at the close position.

Referring to FIG. 7, the base plate 1 tilts or is rotated clockwise to about 5 to 40 degree above horizontal. The angle of rotation is determined by the ability of the solder balls 11 within the ball supply bin 4 to spread out towards the ball gate 5 to maximize ball deposition possibility over the ball grid array template 3 in subsequent steps. The ball gate 5 forms a close wall to keep the solder balls 11 within the supply bin 4.

As shown in FIG. 8, the ball supply bin 4 slides towards the ball grid array template 3 and over the template 3 and in so doing, the solder balls 11 within the supply bin 4 are deposited into the locating holes 12 on the surface of the template 3. The vacuuming means 18 connected to the chamber 13 assist in filling the solder balls 10 into the locating holes 12 on the template 3.

Referring to FIG. 9, the base plate 1 is then tilted or rotated counter-clockwise to about 20 to 75 degree below horizontal. Similarly, the angle of rotation is determined by the ability of the solder balls 11 within the ball supply bin 4 to fall freely by gravity towards the far-end of the bin 4 from the ball gate 5 and by the amount of rotational torque balance at which the ball gate 5 is pivoted about the axis 6.

Due to the fact that the solder balls 11 are typically very small, as small as 0.2 mm diameter, some residual solder balls, denoted as 14, may attach to the surfaces 15 of the base plate 1, the ball grid array template 3 or around the locating holes 12 due to static charges, humidity, contamination or vacuum leakage.

As shown in FIG. 10, at this angular orientation, the ball supply bin 4 slides backwards and in so doing sweeps off excess residual solder balls 14. The solder balls 10 deposited in the locating holes 12 remains in place, held by either vacuum 18 in the chamber 13 or by the depth of the locating holes 12.

CLAIMS

1. An apparatus for filling a ball grid array template having locating holes
5 with a plurality of small solder balls comprising

a base plate rotatably mounted at the axis thereof to a controlling device
and the ball grid array template being mounted onto the base plate so that the
template rotates simultaneously with the base plate;

a ball supply bin slidably mounted over the top surface of the base plate
10 while being rotated together with the base plate, the sliding motion of the ball
supply bin being controlled by a driving means, and the ball grid array template
about the axis of the base plate, and the ball supply bin being substantially
rectangular and enclosed on three vertical sides while the fourth vertical side
proximity to the ball grid array template being a ball gate, said ball gate pivoted
15 about the axis thereof and being normally rested by a stop pin or a stopping
edge, positioned at the lower surface of the ball gate;

a sensing device positioned at both the ends of the base plate at a height
similar to the height of the ball gate from the base plate for monitoring the
opened/closed position of the ball gate; and

20 a plurality of small solder balls enclosed by the ball supply bin
thereby when the base plate tilted towards the ball grid array template, the ball
supply bin slides to and over the ball grid array template and, in so doing, fills
up the locating holes on the template with solder balls, the base plate is then
tilted in the opposite direction, the ball supply bin slides back to the other end
25 and simultaneously, the excess solder balls are fallen back with the supply bin.

2. The apparatus as set forth in Claim 1, wherein the sensing device is a
through-beam sensor or a focused-beam reflective sensor.

30 3. The apparatus as set forth in Claim 1, wherein the base plate is tilted
clockwise in an angle ranging from 5 to 40 degree above horizontal.

4. The apparatus as set forth in Claim 1, wherein the weight of the ball gate is pivoted about the axis thereof so as to form a close wall to contain the solder balls within the ball supply bin.

5 5. The apparatus as set forth in Claim 1, wherein the locating holes on the ball grid array are connected to a vacuum to enhance filling of the solder balls thereto.

10 6. The apparatus as set forth in Claim 1, wherein the base plate is tilted anti-clockwise in an angle ranging from 20 to 75 degree.

7. The apparatus as set forth in Claim 1, further comprising a ball pick head which is lowered above the ball grid array template to remove solder balls by vacuum for transferring to a ball grid array substrate.

15 8. A method of filling solder balls on a ball grid array template having a plurality of locating holes, said method comprising the steps of:
positioning said ball grid array template at one end of a pivotal base plate;
introducing a plurality of solder balls in a ball supply bin which is slidably
20 positioned at the one end of the base plate, and is slidable on the base plate;
clockwise rotating of the base plate, causing the ball supply bin which is controlled by a driving means, sliding towards the ball grid array template to allow the solder balls contained in the ball supply bin to fill the locating holes on the template, each solder ball for each locating hole; and
25 counter-clock wise rotating of the base plate, causing the ball supply bin which is controlled by the driving means driven, to slide back to the initial position of the supply bin and a plurality of solders fill the locating holes, one to each hole.

30 9. The method of Claim 8, wherein the base plate is tilted clockwise in an angle ranging from 5 to 40 degree above horizontal.

10. The method of Claim 8, wherein the base plate is tilted counter-clockwise in an angle ranging from 20 to 75 degree below horizontal.

11. The method of Claim 8, wherein the driving means is a motor.

5

12. The method of Claim 8, further comprising the steps of rotating the base plate in clockwise direction to horizontal position, allowing the solder balls in the template to be transferred for further processing.

10

FIG.1
PRIOR ART

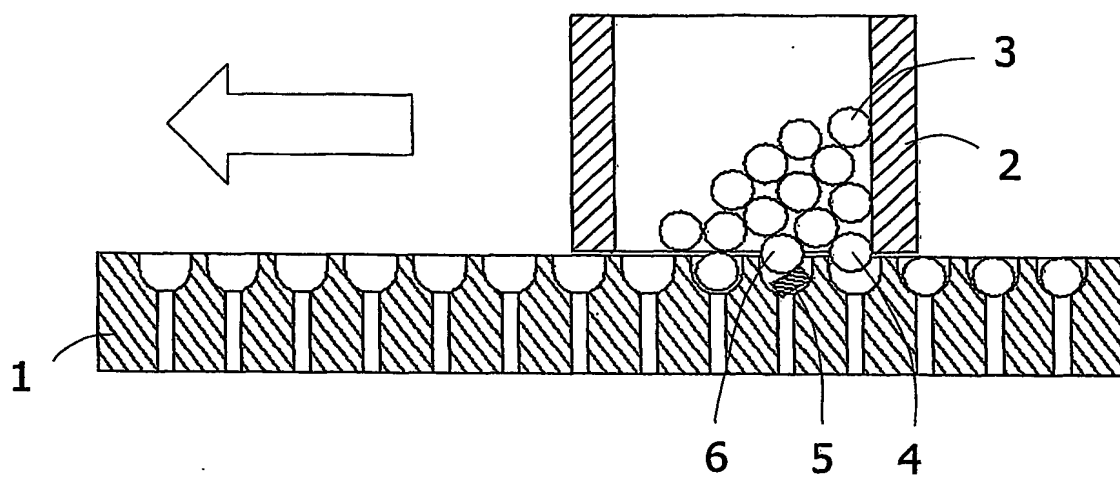


FIG.2
PRIOR ART

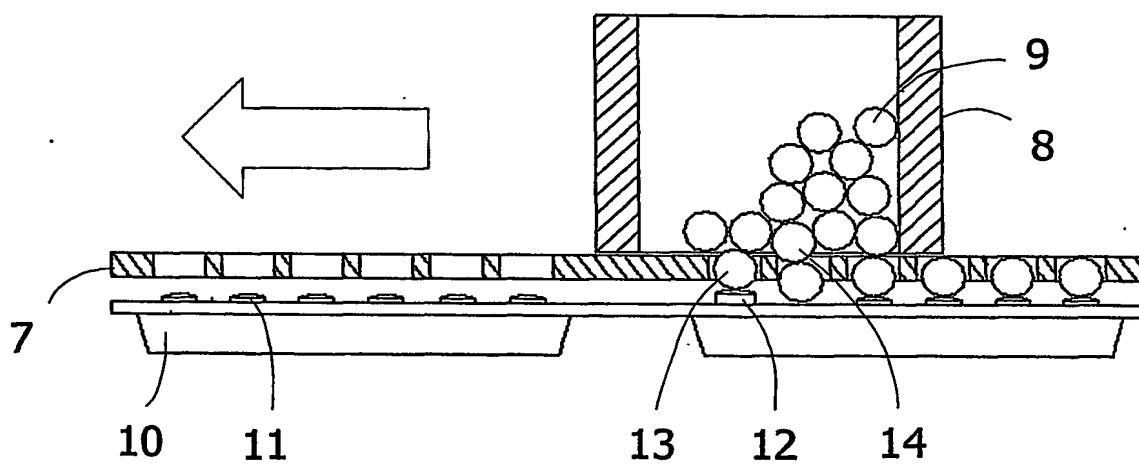


FIG.3
PRIOR ART

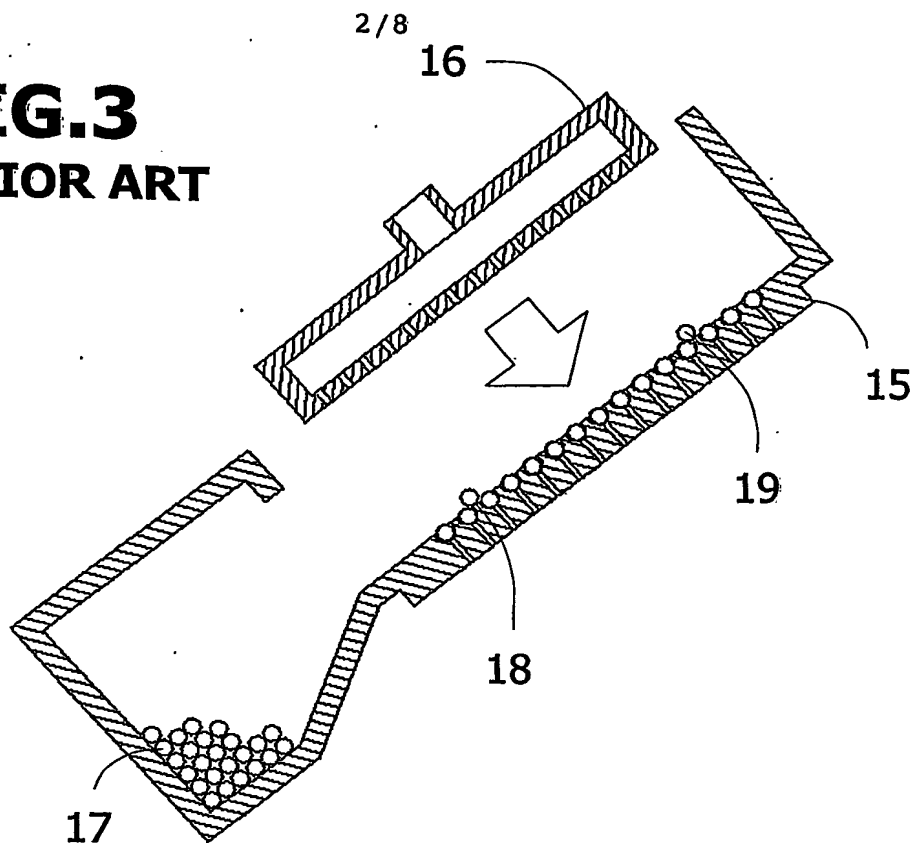


FIG.4
PRIOR ART

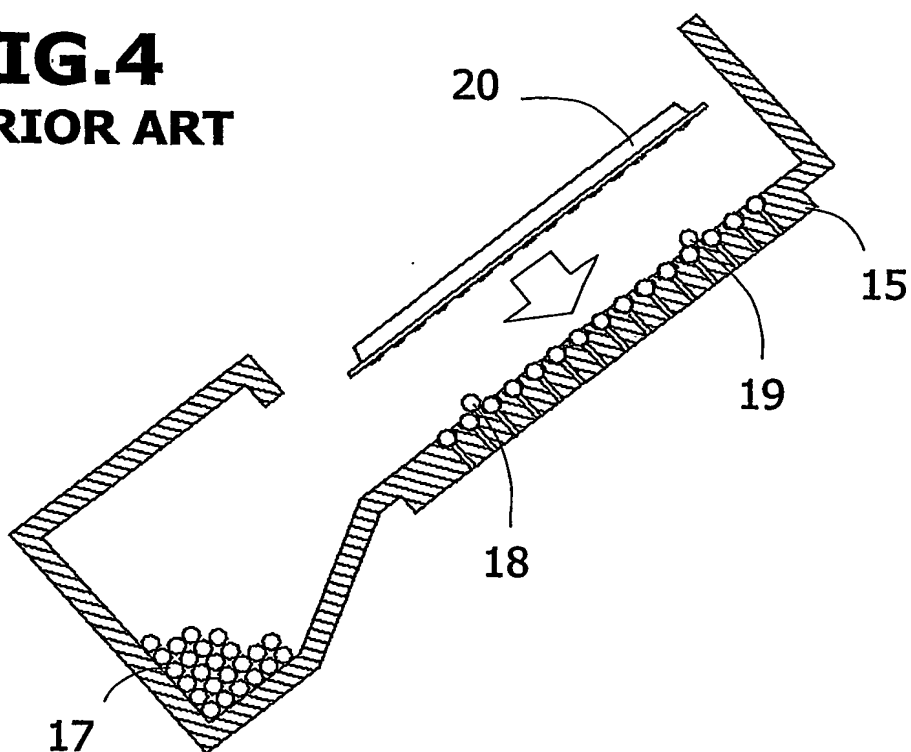


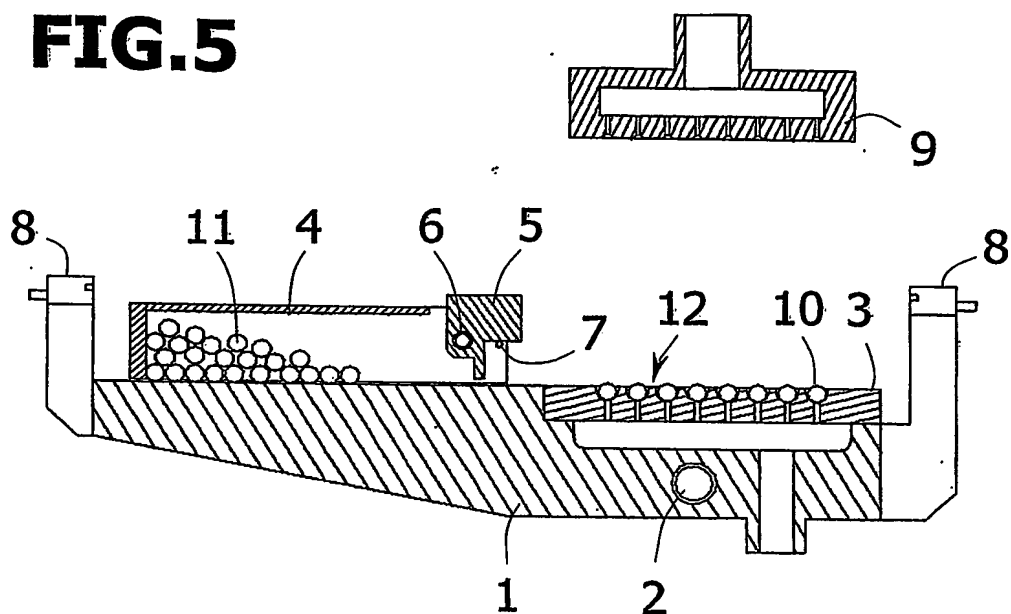
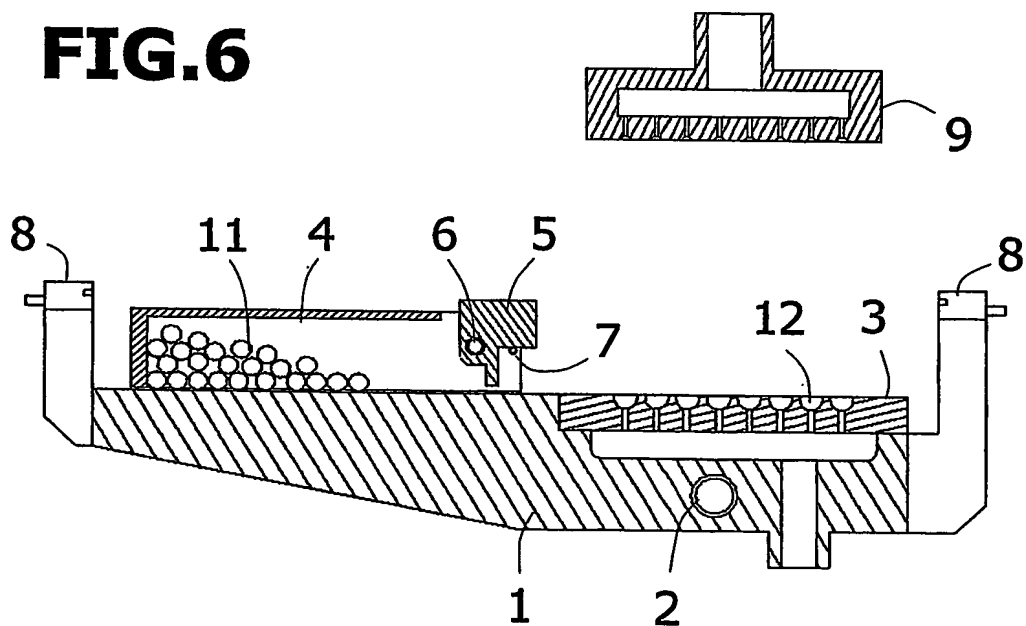
FIG.5**FIG.6**

FIG.7

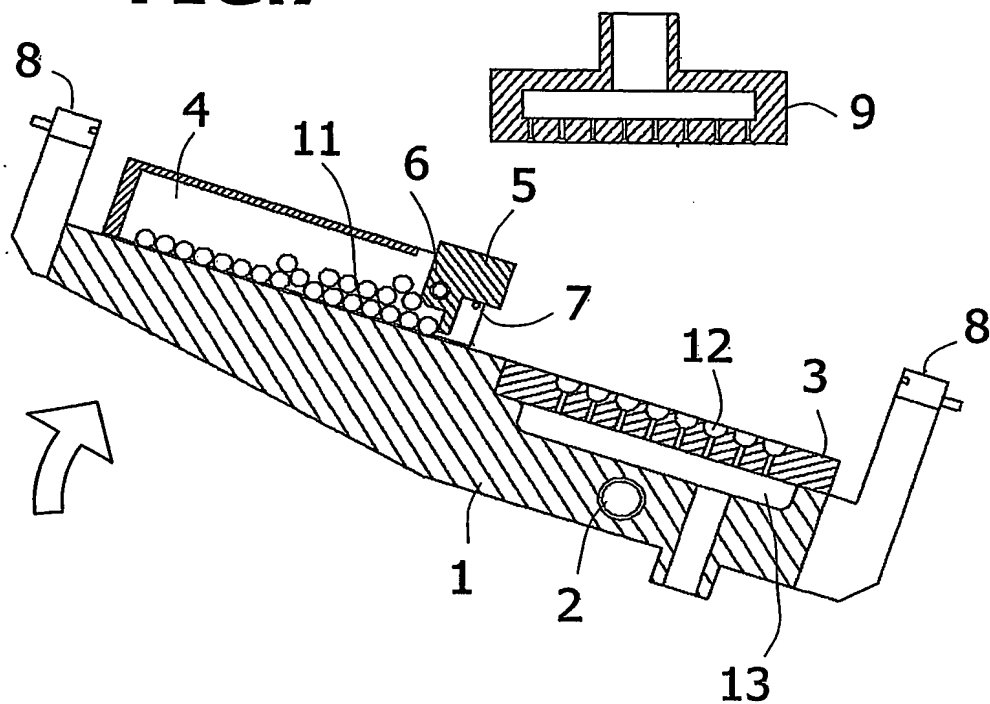
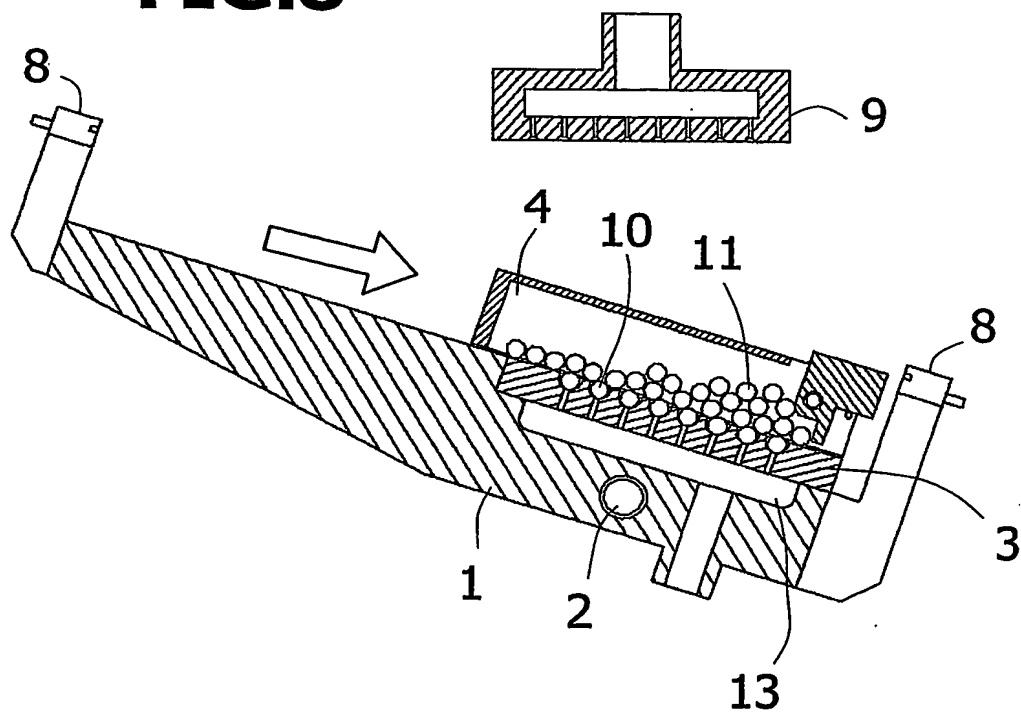
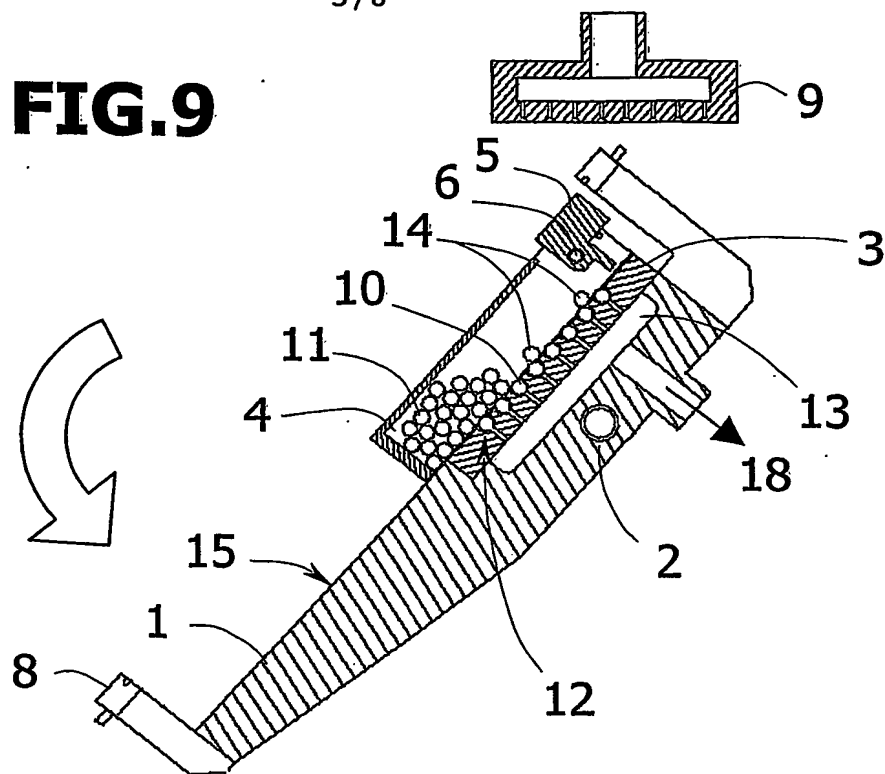
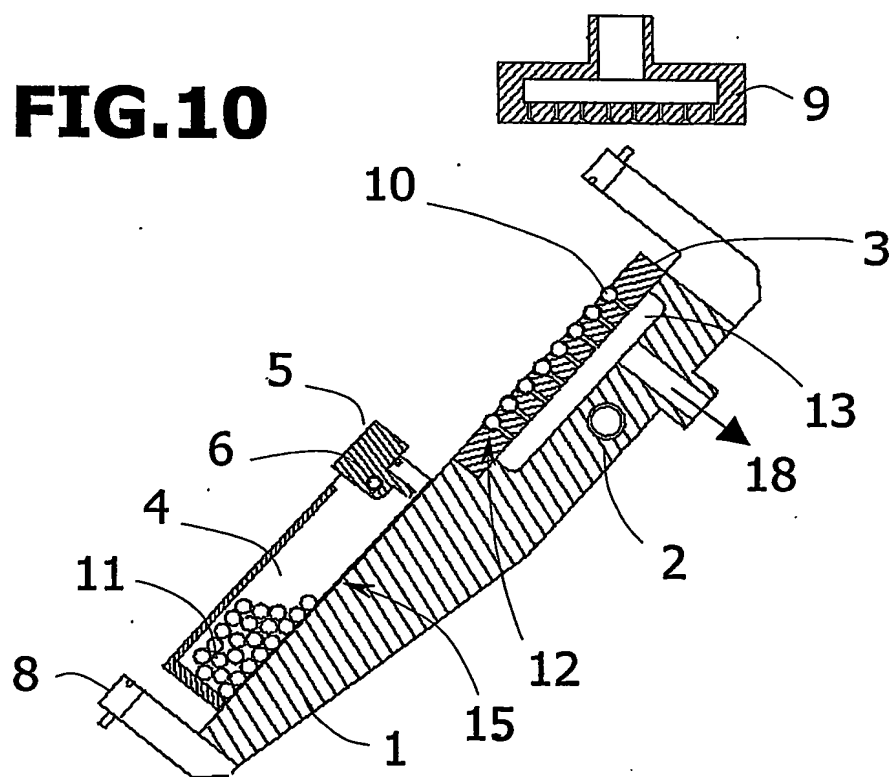


FIG.8



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FIG.9**FIG.10**

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FIG.11

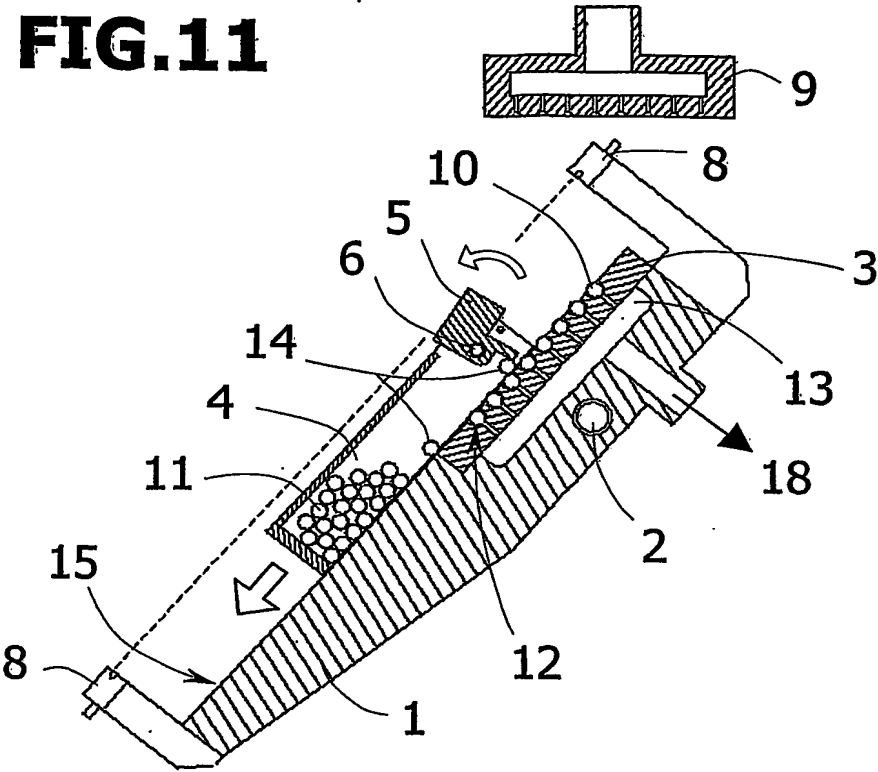
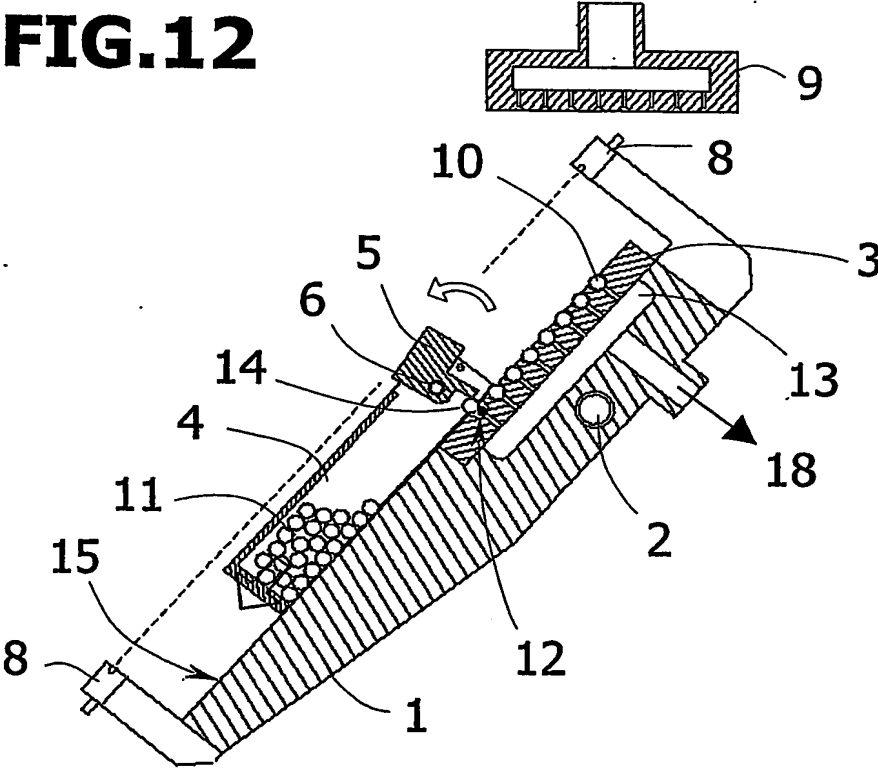


FIG.12



7/8

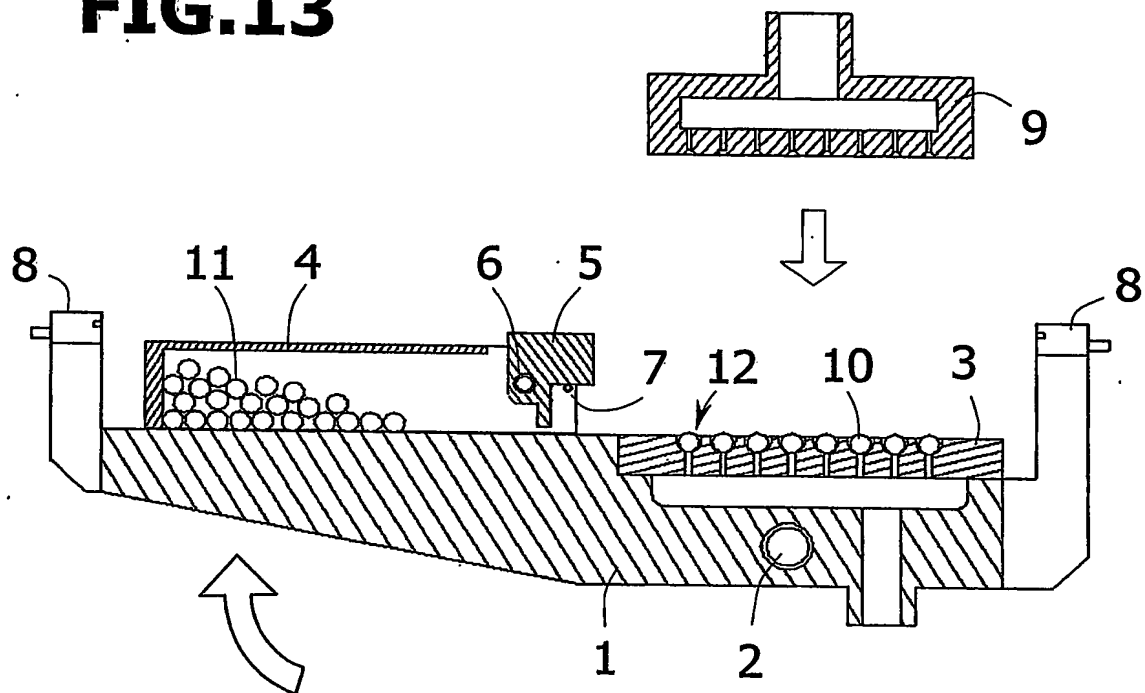
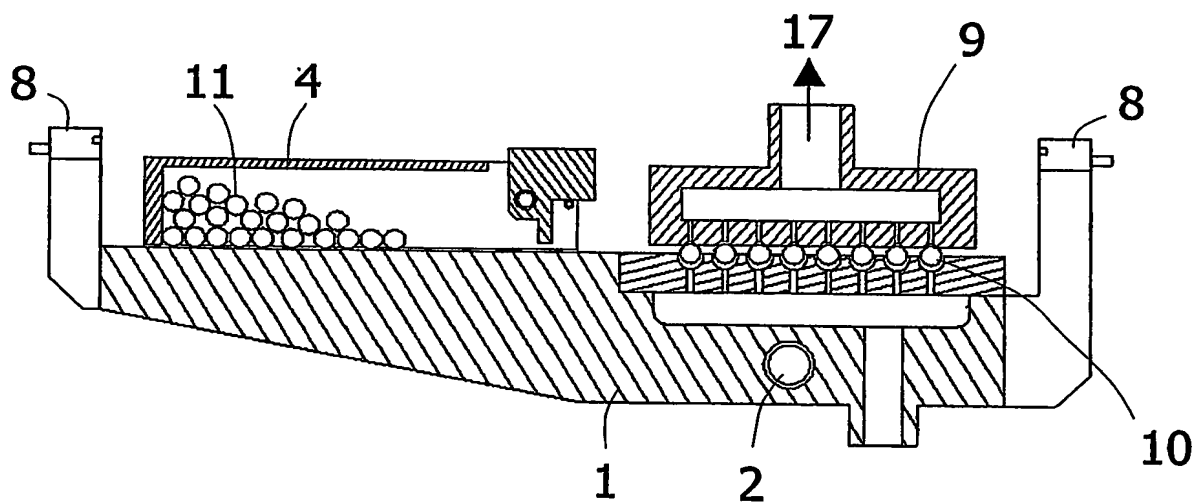
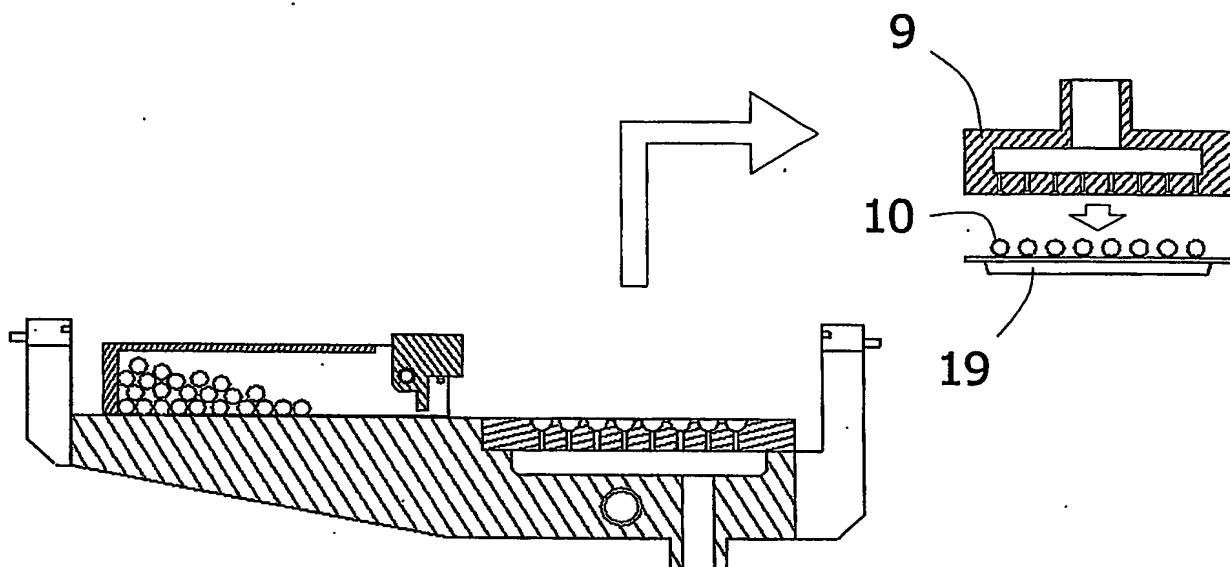
FIG.13**FIG.14**

FIG.15

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SG03/00246

A. CLASSIFICATION OF SUBJECT MATTER				
Int. Cl. ⁷ : B23K 3/06, H01L 21/60				
According to International Patent Classification (IPC) or to both national classification and IPC				
B. FIELDS SEARCHED				
Minimum documentation searched (classification system followed by classification symbols)				
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched				
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) DWPI, JAPIO: solder ball, template, load, fill, tilt, tip, bga, ball array and similar terms				
C. DOCUMENTS CONSIDERED TO BE RELEVANT				
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.		
A	US 6413850 B (OOROKU et al) 2 July 2001			
X	Whole document, figure 4 is particular	1-7		
	Whole document, figure 4 is particular	8-12		
A	US 6276598 B (CHENG et al) 21 August 2001			
	Figures			
A	US 5941449 A (LE COZ et al) 24 August 1999			
	Figures			
<input checked="" type="checkbox"/> Further documents are listed in the continuation of Box C <input checked="" type="checkbox"/> See patent family annex				
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<p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier application or patent but published on or after the international filing date</p> <p>"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p>	<p>"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</p> <p>"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone</p> <p>"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art</p> <p>"&" document member of the same patent family</p>			
Date of the actual completion of the international search 5 December 2003		Date of mailing of the international search report 11 DEC 2003		
Name and mailing address of the ISA/AU AUSTRALIAN PATENT OFFICE PO BOX 200, WODEN ACT 2606, AUSTRALIA E-mail address: pct@ipaustalia.gov.au Facsimile No. (02) 6285 3929		Authorized officer GREG POWELL Telephone No : (02) 6283 2308		

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SG03/00246

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	Derwent Abstract Accession No. 1999-538647/45, Class L03, SG 65625 A (MOTOROLA INC) 22 June 1999 Abstract	
A	WO 00/54921 A (NOVATEC SA) 21 September 2000 Figures	
P, A	US 2003/127501 A (CHENG et al) 10 July 2003 Figures	1-7
P, X	Figures	8-12

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/SG03/00246

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report		Patent Family Member			
US	6413850	JP	2001-148395		
US	6276598				
US	5941449	US	5762258		
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		FR	2798309	US	6604673
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END OF ANNEX					